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AWARENESS AND ADOPTION OF BUILDING INFORMATION MODELLING IN NIGERIA: A STUDY OF ARCHITECTURAL PRACTICES IN OWERRI, IMO STATE

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Abstract

To ensure the realization of a highly efficient and collaborative process in the planning, design, and construction of buildings, all over the world, Building Information Modelling (BIM) is becoming an imperative and even required practice in the building industry. To compete, architects in Nigeria need to update their knowledge of the current standards. The study sought to investigate the adoption of BIM in Owerri, Imo State, Nigeria. The method for gathering data was survey method, through the administration of questionnaires. The target population was the all persons (148) on the membership list of the Nigeria Institute of Architects (NIA), Imo State Chapter in 2020. 55 non-repetitive responses to the survey were received. The results of analysis of data revealed that the respondents had a high level of awareness of the terms associated with BIM but low levels of adoption. The study also showed that the majority indicated that lack of knowledge was the major hindrance. Also, the greater proportion did not agree that the non-availability of equipment and infrastructure were major hindrances. The implications of these findings were that, for improved awareness and adoption of BIM in the study area, the NIA should organise BIM training workshops for her members; architectural education regulators should reinforce inclusion of BIM training in architectural education curricula; and government should partner with industry stakeholders to create enabling legislation on standards and use of BIM.

Keywords: Adoption, Architecture, Awareness, Building Information Modelling, Construction

INTRODUCTION

The language of architectural design and drawings has continually evolved throughout the history of the profession. The emergence of a new means for the communication of ideas often triggers off a revolution in the industry and creates the need for practitioners to acquire new knowledge and infrastructure in order to compete and remain relevant. This, evidently, is the case with the advent of Building Information Modelling (BIM). Initially, architects conveyed their intentions about aspects of a building through hand-drawn 2-dimensional (2D) drawings. This method proved very difficult to visualize dimensions, and communicate information regarding fit and potential issues that may arise when built. The only way to spot such issues was to build physical models. The invention of Computer-Aided Design (CAD), in a digital environment, brought with it many benefits over manual drawings. Some of these included increased productivity, higher quality designs, easy reuse of, or changes to design, convenient documentation and simplified sharing and storage (Hobbs, 2018). With the advent of CAD came also the introduction of 3-dimensional (3D) realistic visualization to drawings. However, BIM, which is fast becoming the standard, as a tool, takes this knowledge of 3D and its utility farther (Lorek, 2018; Hobbs, 2019).

The pace of this obligatory change in the mode of practicing architecture has been increased by globalization, a concept whose meaning has been further defined, not only by the ease of intercontinental travel, but also by the advent and spread of the internet. Also, McGraw Hill Construction (2014) showed that contractors around the world who invested in BIM reported (amongst other benefits) fewer errors and omissions, less rework and lower construction costs, i.e. reduction in wastes. This can be attributed to working collaboratively in a BIM environment. Indeed, Lorek (2018) avers that around the world, BIM is becoming an important and required process for ensuring that the planning, design, and construction of buildings is highly efficient and collaborative. It is therefore imperative that architects keep abreast with the new paradigms of design and construction in the industry.

Though BIM practice has not become law in any part of Nigeria, the practice of architecture in this country is not unaffected by these trends. This assertion is corroborated by such studies as Hamma-adama, Salman, and Kouid (2017) which reported that 61.9% of architects in Nigeria were aware of BIM. The drive to acquire new knowledge would entail a renewed focus on informing, educating and training of architects. It is important, therefore, that those involved in training architects understand this trend and refocus the content of curricula to prepare their products for a fast-changing world. Also, it is noteworthy that the adoption of BIM may be negatively affected by absence of several factors associated with successful adoption of CAD technologies. Among these are availability of infrastructure; cost of equipment and availability of tutors who are knowledgeable about the technologies (Begho, 2010; Osakwe, 2012). It was thus relevant in this study, not only to clarify the issues of awareness and adoption, but also to examine the influence of some of these key factors in the levels of adoption in the population.

Owerri, the location of the study, is the capital city of Imo State, Nigeria and host to a vibrant State chapter of the Nigeria Institute of Architects (NIA), the umbrella body of the architecture profession in Nigeria. It was chosen as the focus of this research because it is the main hub of organised architectural practice in the State. Also, it is where the NIA has its sole functioning forum/branch in the State. The data gathered from the sample, therefore, is most representative of architectural practice in the area. Being of such importance, the issues surrounding BIM awareness and adoption are germane for architects there. Hamma-Adama and Kouider (2018), while documenting key available research on BIM within Nigeria, noted that most surveys were done in the major cities of Lagos, Abuja, Kaduna and Kano. It is perhaps because these major urban centres house the greater proportion of built environment professionals in the country. Whereas a few other studies have also been conducted in some southern states, none has been done in Imo State. The lack of data on the state of affairs in many other parts of the country like this State leaves an incomplete picture. It is expected that the inclusion of data from these unresearched areas would lead to a more complete knowledge base, a vital tool for decision makers in the industry. This research sought to fill some of this gap.

The study was part of a wider research on new trends that would influence a review of architectural education curriculum in Nigeria. Its specific objectives were (i) to investigate the level of awareness and adoption of BIM practices in the study area (ii) to examine the impact of specific factors on adoption of BIM amongst architects in the study area. The specific factors were knowledge of BIM, cost of BIM equipment, availability of BIM equipment and availability of training opportunities. For the purposes of the study, awareness is defined as knowledge that something exists, or understanding of a situation or subject at the present time based on information or experience (merriam-webster.com, 2022; Cambridge University Press, 2022). Similarly, adoption is defined as the act of accepting, embracing, or starting to use something, as an idea, behaviour, characteristic, or principle (Dictionary.com, 2022), in this case the BIM process. This would include any level of use that comes under the purview of the BIM process. It was expected that the results of the study will provide clarity on the status of these variables in the study area and thus give impetus to improvement of architectural practice through education, legislation, and community mobilization.

LITERATURE REVIEW

BIM has been defined as a highly collaborative process that allows multiple stakeholders and architecture/engineering/construction (AEC) professionals to collaborate on the planning, design, and construction of a building within 3D models. Data created, modified and added to by the several professionals involved are used in the operation and management of buildings. These data allow owners and stakeholders to make decisions based on pertinent information derived from the model- even after the building is constructed (Lorek, 2018). Similarly, Autodesk Inc (2019) describes it as a process that begins with the creation of an intelligent 3D model and enables document management, coordination and simulation during the entire lifecycle of a project (plan, design, build, operation and maintenance). Over time, different vendors have developed several application software that enable seamless conduct of the various activities involved in the BIM process. These software tools have become closely associated with the BIM phenomenon. Examples of these tools include Autodesk Revit, Autodesk BIM 360, Graphisoft ArchiCad, Vectorworks Architect, Bentley Systems Microstation, Autodesk Navisworks (constructionplacements.com, 2022)

The following theoretical concepts were found relevant for understanding the phenomenon being investigated in the study;

1. *The diffusion of innovation theory*:

This theory was first introduced by Everett Rogers in 1962. It states that innovations, or new ideas, will spread through a society based on three main factors: Diffusion of Innovations (the change in sales volume over time), the rate of adoption (the percentage of people who adopt an innovation in a given period), and Innovation intensity (the number of adopters per individual innovator) (neostrom.in, 2022). The concept explains how innovations are perceived by society and by what means the acceleration of their adoption can occur. It highlights that the adoption of an innovation within society is not uniform across it and avers that innovations spread through society following a series of phases. Just as with any other product an innovation needs to be introduced to the different groups in society before it can become widely accepted. This is because people will often only change their opinion of something when they see other people around them also changing their opinion of it. According to lectera.com (2022), the main components of Rogers' theory are: (i.) *Innovation* - the concept describing any ideas and technologies that are new to users. In this study, this would refer to 'Building Information Modelling'; (ii.) *Users* - the audience that embraces the innovation. In the study, this refers to the Architects in the study area; (iii.) *the critical mass of users* - a sufficient number of people who actively use the innovation to trigger its widespread adoption. This would refer to the Architects in the study area who have adopted BIM in some form; (iv.) *the process of innovation adoption* - a process consisting of five steps that leads to the acceptance or rejection of mass use of a new idea/technology; and (v.) *additional key factors* - factors which play a role in the process of innovation adoption: communication, the social system, and time.

2. *The Technology–Organization–Environment (TOE) Framework*

Baker (2012) describes TOE as an organization-level theory which posits that three elements of a firm's context influence technological innovation and adoption decisions by it. The first is the technological context, which includes all available technologies that are relevant to the organization – whether they are already in use at the organization or not. In the light of this context, organizations must judiciously consider the type of changes that will be triggered by the adoption of a new innovation. This is because some innovations will have a huge impact on it and the industry in which it competes, while the impact of others will be relatively small. The second is the organizational context which refers to the characteristics and resources of the organization, including structures which link employees, size of firm, intra-firm communication processes, and the amount of slack resource. The third is the environmental context which includes the structure of the industry, the presence or absence of technology service providers, and the regulatory environment (Baker, 2012).

These theories are relevant for understanding the levels of awareness and adoption of BIM in the study area. This is because BIM is a new innovation/technology in the context and adoption has been documented to vary across climes. The contextual elements identified under TOE have indeed been confirmed in literature to be influential in the adoption process. The theory therefore helps give clarity to issues that ought to be the focus for investigation. The variables investigated were chosen with this background in mind.

Literature shows that BIM adoption is increasing around the world. Wan Mohammad, Abdullah, Ismail, and Takim (2018) underlines this increase, particularly by commercial contractors. It also highlights the increase in adoption rate in North America from 28% (2007) to 71% (2012) with building contractors having the highest rate (74%) followed by architects (70%) and engineers (64%). It is notable that the United Kingdom Government made Level 2 BIM a mandatory requirement on all publicly tendered projects in April 2016. It also committed to making Level 3 BIM a prerequisite for all projects in the coming years. Many other countries have established standards mandating BIM to be used on new building and infrastructure projects. Some of these are Brazil, Chile, Denmark, Finland, Norway, South Korea, Singapore and Vietnam (Autodesk Inc, 2019; Lorek, 2018).

While reporting on the Australian construction industry, the Department of Innovation, Industry, Science and Research (2010) concluded that the uptake of technologies such as Building Information Modelling (BIM) was ‘becoming an increasingly important factor in the efficiency and international competitiveness of the country. It explained that ‘international activity indicates global markets view BIM as an important tool for the future growth and competitiveness of the built environment. This highlighted the need for the industry to embrace change (Department of Innovation, Industry, Science and Research (2010) in Newton & Chileshe (2012).

Conversely, literature has also highlighted a number of studies (Gambatese & Hallowell, 2011; Lawrence & Scanlan, 2007; Yang, 2007) which reported the reluctance of the construction industry to adopt new technologies (Newton & Chileshe, 2012). Besides, in a study of individuals in Australia, who successfully implemented technical innovations, some factors were identified as factors that enabled construction innovations within the context of small and medium enterprises. These included (1) company resources; (2) client and end-user influence; (3) project-based conditions; (4) Industry networks; and (5) regulatory climate (Hardie & Newell (2011) in Newton & Chileshe (2012)). These lessons could prove germane for policymakers in Nigeria as they seek to improve productivity through the implementation of new technologies. Newton and Chileshe (2012) also stated that increased education and awareness of BIM was necessary for more wide-spread adoption in the South Australian industry. This contrasts with existing studies of developing nations (Jung & Lee, 2015), particularly, Nigeria (Hamma-adama, Kouider, & Salman, 2018) which reported low rates of adoption.

A review of other surveys on adoption and use of BIM across the world indicated the following; that in 2012, 71% of architects, engineers, contractors and owners in the USA indicated that they used BIM on their projects (Edirisinghe & London, 2015); while 53% of architects in a 2014 survey of South Africa reported the same (Froise & Shakantu, 2014). Jung and Lee (2015) described a limited survey of BIM adoption among 6 continents. The results indicated the continents that had the most far-reaching BIM implementation rates in the following descending order: North America, Oceania and Europe, Middle East/Africa, and South America. Literature, also reported advanced adoption rates with significant benefits in construction project delivery in countries like USA, UK, Australia, Netherlands, Norway, Finland, Denmark, Singapore, Hong Kong (Kori & Kiviniemi, 2015; Lorek, 2018).

A further examination of the experiences of the advanced adopters like the USA, UK and Australia showed similar associated factors that facilitated their progress in adoption of BIM. First, there was the specific involvement of government through such instruments as (a) the establishment of the National 3D-4D-BIM Program in 2003 by the General Services Administration (GSA) in the USA (Edirisinghe & London, 2015); (b) The development of a Task Group by the UK government to support transitioning to BIM and the enactment of legislation to facilitate its adoption (Hamma-adama & Kouider, 2019; Edirisinghe & London, 2015); (c) The establishment of National Building information Modelling Working Party in Australia. This body was to report on BIM activities to the Built Environment Industry Innovation Council (BEIIC). On the other hand, there is no documentation of such involvement of the Nigerian government in promoting BIM adoption in Nigeria. No specific body or legislation exists to drive the process, rather, interest in it is industry driven.

Second, there was the availability of ICT infrastructure in these countries. This facilitated quick development and adoption of BIM within their AEC industries (Hamma-adama & Kouider, 2019). In comparison, Nigeria continues to struggle with the deployment of the vital infrastructure needed. Third, there was the involvement of educators and trainers of the practitioners in the industry. Hamma-adama and Kouider (2019) also reported that the USA had begun BIM education in 2002, when many countries were yet to acquire sufficient awareness of the concept at industry level. Similarly, in Australia, a project on BIM technologies known as 'collaborative design education - CODE BIM' was supported by the Australia Government Office for Learning and Teaching. Three of the nation’s universities were engaged for this. A complimentary framework to help Academics to implement BIM training was developed. By comparison, there is no government supported BIM implementation scheme which involves the academic community in Nigeria.

On the other hand, a review of the literature on BIM for construction in developing countries showed that there existed relatively little BIM related research from most developing countries other than China, India, and Malaysia (Buiab, Merschbrockb, & Munkvold, 2016). Buiab, Merschbrockb and Munkvold (2016) noted, therefore, that there was a need for research in this area as well as the need to create local customized BIM software adaptations for developing countries. It listed the shortage of IT-literate personnel and the absence of national BIM implementation programs as examples of issues preventing BIM adoption in these countries. Perhaps as part of efforts to fill the gap in knowledge and drive uptake, the BIM Africa organization has been conducting biennial surveys from 2020. In its 2022 report on the state of BIM practice in the continent (BIM Africa, 2022), it indicated that while BIM awareness was high, adoption was still low (below 50%). A comparison with the BIM Africa 2020 report shows that the results were similar. These results were from an Africa-wide survey of over 1100 respondents, 27 % of whom were from the West African region. It is therefore germane that similar, local, studies be encouraged, so as to understand the state of affairs at these levels

Meanwhile, with regard to the Nigerian construction industry, Ibem, et al (2018) reported that studies on BIM found in literature, were fragmented. One major flaw, it identified, was that these studies did not recognize the uniqueness of the different professions in the industry. As such, they were all treated as a monolithic entity. Hamma-Adama and Kouider (2018), similarly, described this body of research as limited to specific cities and disciplines. Alike, Dare-Abel, Igwe, and Ayo (2014) described a survey of architectural firms across the country. A sample of six firms from the six geopolitical zones of the country was chosen. It stated that 75.4% of firms surveyed had BIM literate personnel in their employment. This indicated high awareness, but not necessarily high adoption. Documented case studies of actual usage did not accompany these studies.

From a survey of architects and firms in Lagos, Ibem, et al (2018) affirmed that there was increased awareness (97% of respondents in the study) and use of BIM software packages, particularly among the younger ones. It attributed this to the incorporation of BIM in the curricula of architecture schools. It, however, did not discuss the extent of this incorporation. It also indicated a limited use of BIM tools for analyses when compared to its use for design and drafting and its increasing significance in architectural practice. It noted, meanwhile, that design and drafting were carried out with non-BIM software. Also, while reporting a survey of AEC professionals in Lagos State, Ogunmakinde and Umeh (2018) showed that 58% were aware of BIM, while 44% indicated they used BIM software. Hamma-adama, Salman, and Kouider (2017) reported a limited survey of architects in Nigeria which indicated that 61.9% were aware of BIM, but only 26.9% used some form of it. Considering the size of Nigeria, more local studies on the status of awareness and adoption in other places would assist in building a more complete picture.

A working description of the nature of BIM was found to be vital in seeking information about adoption practices. Several similar categorizations of levels exist in literature (DPR Construction, 2010; Victor, 2019). Mandhar and Mandhar (2013) asserted that varying interpretations hindered adoption, hampering improvements in the construction industry. Other sources do not corroborate this. For the purposes of this study the Bew-Richards BIM maturity model described by Amuda_Yusuf, Adebiyi, and Isa (2018) was adopted. This classified BIM levels as starting from 0 and going to Level 3. This was chosen because it is the system used in the United Kingdom, which Nigeria draws her building standards from.

As a way of measuring how much information is being shared and managed or how effectively this is being done throughout an entire project, this model divided the BIM process into levels. Each level represents a different set of criteria that shows a particular level of 'maturity' in the process. By examining a project cycle using this template, it is possible to state which level has been attained in it. Also, different levels of BIM are achievable for different types of projects. The following is a brief description of the four levels of categorization in the Bew-Richards model:

(i) Level 0 BIM: This is the lowest level of the categorization method adopted. At this level, the AEC professionals working on a project are using 2D CAD tools to produce drawings much like what has been done for ages. The only difference is that the drawings are in digital format and can be stored and transmitted electronically. One professional (e.g. the architect) must usually finish before the other (e.g. the engineer) can proceed with their part. There is no collaboration during the drawing process. The zero (0) number affixed to this level implies that BIM is not applied at all (Victor, 2019; McPartland, 2014; Mordue, 2019).

(ii) Level 1 BIM: At this second level, the AEC professionals working on a project use 3D CAD for conceptual work and 2D CAD for drafting production information and other documentation. At this level, data is shared electronically using a common data environment (CDE). This CDE is managed by the project contractor, who facilitates the limited collaboration. Meanwhile, each stakeholder publishes and manages its own data, while drawing data from the centralized information source (McPartland, 2014; Mordue, 2019).

(iii) Level 2 BIM: At this third level, the stakeholders begin to work in a more collaborative environment during each stage of the project cycle. All the parties may create/use their own local 3D CAD models. Sometimes the same model is distributed electronically. Information is shared using an agreed common file format. It is this way of exchanging information that differentiates this level from other levels described. Since data is shared this way, each party must ensure that their CAD software is capable of exporting to the agreed format. This allows them to combine external data with their own data, seamlessly. They are then able to create a 'federated' BIM model, thus saving time, reducing costs, and eliminating the need for rework (Victor, 2019; Mordue, 2019).

(iv) Level 3 BIM: At this fourth level, the stakeholders become even more collaborative. Instead of each team member working with their own 3D model, everyone uses a single, shared project model. The model (usually created by the architect) is stored in a 'central' digital repository and can be accessed and modified by everyone. All the parties are able to work simultaneously on it and any changes by one party are immediately updated for the other parties. This concept, also called Open BIM, eliminates the chance of conflicting information emanating from any party, thus adding value to the project at every stage (Mordue, 2019; McPartland, 2014).

Notwithstanding that the use of ICTs like BIM had become imperative, adoption rates in the AEC industry were negatively affected by multiple factors. Some of such factors indicated in literature included inadequate infrastructure (Achimugu, Oluwagbemi, & Oluwaranti, 2010; Begho, 2010), lack of necessary computer skills (Begho, 2010), and lack of funds for ICT Infrastructure and Training (Osakwe, 2012). In a study of adoption of BIM in the Nigerian AEC Industry, Ogunmakinde and Umeh (2018) reported seven factors as the top barriers to uptake of the technology. In descending order, these were Lack of awareness; Lack of trained professionals; Cost of software; Lack of clients' demand; ICT illiteracy; Cost of training and Lack of adequate ICT infrastructure. Hamma-Adama and Kouider (2018) similarly identified lack of trained staff and lack of awareness as the key barriers to adoption in Nigeria.

Furthermore, Onungwa and Uduma-Olugu (2017) observed like factors in a survey of construction professionals in Lagos and its environs. These included Industry Lack of skilled personnel; Lack of internet connectivity; Reluctance of other stake holders to use BIM; Lack

of BIM Object Libraries and Lack of awareness of technology. The perceptions reported by Abubakar, Ibrahim, Kado, and Bala (2014) following a study of AEC professionals in Abuja, Nigeria, were also similar. They included Social and Habitual Resistance to Change; Legal and Contractual Constraints; High Cost of Training; Lack of Enabling Environment (Government policies and legislations); Lack of Trained Professionals to handle the tools; Clients not requesting the use of BIM on projects and No proof of financial benefits.
Drawing from these, an examination of the perception of respondents about several factors that hindered adoption in the study area was also carried out. The factors examined were lack of knowledge among architects; cost of purchasing computer equipment and infrastructure; unavailability of required computer equipment and infrastructure and lack of training opportunities. This investigation was considered important as the information obtained would assist in policy making.

To improve the adoption of BIM, Zhang, Chu, He, and Zhai, (2019) suggested that authorities and government should formulate regulations that will clarify the application standards of BIM technology. They also suggest that firms should increase technical training for employees so as to acquire greater understanding of BIM and sustainable building. In addition, more awareness should be created among BIM users so as to increase the degree of perceived satisfaction and enhance the willingness to adopt it. Like CAD at its arrival, BIM has clear benefits, and its practice is expected to thrive. Examples of such benefits as highlighted by Wong and Fan (2013) are integrated project delivery and design optimization. It is expected that studies like this one will aid to fill the existing gap of knowledge of the status of BIM awareness and adoption in a developing country like Nigeria. It is hoped that as awareness and education increases, lessons learnt in other parts of the world will be leveraged on to make the necessary transition to the new technology.

RESEARCH METHODOLOGY

The variables defined in the study were subjected to investigation in a field survey and their observed outcomes constituted the data for the research. The questionnaire was the instrument of research used for data gathering. It was designed to elicit response on the pertinent issues of the research variables. The research involved the study of all registered architects and architectural technologists who practice in Imo state, Nigeria. Owerri is the capital city of Imo state and the location of the secretariat of the state chapter of the Nigeria Institute of Architects (NIA). Hence, information on the target population was sourced through the secretariat. Data gathered showed that the Imo State chapter of the NIA had about 148 members on its register in 2020.

All members on the register were targeted for responses. The scattered locations, the high mobility of the architects, and limitations imposed by the COVID 19 pandemic (in 2020) necessitated the application of a combination of methods for obtaining responses from as many respondents as possible. These methods included first, the administration of physical copies of the questionnaire to architects who attended the monthly in-person NIA meetings during the period of the field survey; sixteen (16) responses were received though this way. The second method was the circulation of a digital version of the questionnaire to architects who were not available in the meetings (this was done through email and WhatsApp messenger platform); Five (5) responses were received through this process. The third method involved the creation of an online Google form version of the questionnaire (the link was circulated to members). Thirty-four (34) responses were received through this method. A total of fifty-five (55) non-repeated responses were received (37% of the population). This outcome raised the possibility of non-response bias. However, it was not considered significant as to necessarily impact the conclusions from the study. This was so because when checked with the information available from the NIA secretariat it was found that the socio-demographic data was consistent with that of the entire population. Also, this size of response was found to be similar to other reported studies which followed comparable methods of data gathering (Jung & Lee, 2015; Amuda_Yusuf, Adebiyi, & Isa, 2018; Newton & Chileshe, 2012). Variables chosen for inclusion in the study were chosen based on similar studies reported in literature. Data was presented using descriptive statistics.

PRESENTATION OF RESULTS

A. Socio-demographic characteristics

Results of the analysis of the category of respondents who returned responses showed that most were architects, while a small minority were architectural technologists (see Table 1). The greatest proportion worked as lecturers in architecture schools, followed by a sizeable proportion in architectural firms. The smallest proportions worked in non-architectural companies, government offices and independent freelance practice (Table 1). When their 'years since graduation' was examined, it showed that almost half of respondents had clocked above 15 years since graduation. The 0-5 years and 6-10 years' categories had one fifth share each, with the 11-15 category having the least number (Table 1).

Table 1: Socio-demographic characteristics

Value label	**Frequency**	**Percent**
Category of respondent		
Registered architect/Graduate architect	53	96.4
Architectural technologist	2	3.6
Total	55	100.0
Primary place of work		
Architectural Consultancy firm	17	30.9
Other private (non-architectural) company	4	7.3
Education (lecturer in polytechnic or university)	22	40.0
Government office (local/state/federal)	3	5.5
Independent practice	9	16.4
Total	55	100.0
Years since graduation		
Value label	Frequency	Percent
0 – 5 years	11	20.0
6 – 10 years	11	20.0
11 – 15 years	8	14.5

Above 15 years	25	45.5
Total	55	100.0

Source: Fieldwork, 2019

B. Awareness and use of BIM

Results of analysis of variables measuring awareness and use of BIM were thus: Almost all respondents (94.5%) reported knowing the meaning of the term 'BIM', while a very small proportion (5.5%) reported either not being sure or no knowledge (see Table 2). Two thirds of respondents indicated they applied BIM tools in their practice, while one third indicated they didn't or were not sure (Table 2). When questioned on the BIM software they used, about two thirds indicated using either Revit or ArchiCAD, the relevant software available in the study area, while a quarter indicated using the two. Only a small proportion (10%) indicated they did not use any BIM software (Table 2).

Table 2: Common knowledge and use of BIM software

Value label	**Frequency**	**Percent**
Knowledge of the meaning of the term 'Building Information Modelling'		
Yes	52	94.5
Not sure	2	3.6
No	1	1.8
Total	55	100.0
Use of Building Information Modelling in architecture practice		
Yes	37	67.3
Not sure	4	7.3
No	14	25.5
Total	55	100.0
Which BIM software is used: (i) ArchiCAD (ii) Revit (iii) Others		
None of the above	7	12.7
one only: either (i); (ii) or (iii)	33	60.0
two only: either (i) & (ii); (ii) & (iii) or (i) & (iii)	14	25.5
All of the above	1	1.8
Total	55	100.0

Source: Fieldwork, 2019

In tandem with BIM categorisation by levels, respondents were investigated on their awareness and use at each level. The results showed that most applied BIM 0 (used BIM software primarily for producing drawings); a small proportion (10%) didn't (see Table3). The same proportion (90%) was aware of BIM 1 but only a minority (10%) indicated applying it in their work. About three quarters of the respondents indicated knowledge of BIM 2 but less than one fifth indicated applying it in their work. The results were the same for questions on knowledge and involvement at BIM 3- three quarters of the respondents indicated knowledge, but only a small proportion claimed application in their work (see Table3).

Table 3: knowledge and involvement at BIM levels

Value label	**Frequency**	**Percent**
Use of BIM software primarily for producing drawings (BIM 0)		
Yes	49	89.1
No	6	10.9
Total	55	100.0
Knowledge that BIM software is used to create 3D CAD for concept work, but 2D CAD for drafting production information and other documentation- Not much collaboration (BIM 1)		
Yes	49	89.1
No	6	10.9
Total	55	100.0
Application of BIM software for BIM 1		
Yes	16	29.1
No	39	70.9
Total	55	100.0
Knowledge that all team members can use 3D CAD models in BIM software in a collaborative way but not necessarily in the same model- Information is shared through a common file format (BIM 2)		
Value label	Frequency	Percent
Yes	40	72.7
No	15	27.3
Total	55	100.0
Application of BIM software for BIM 2		
Yes	10	18.2
No	45	81.8
Total	55	100.0
Knowledge that BIM software can be used by stakeholders to fully collaborate in a single, shared project model which exists in a 'central' environment and can be accessed and modified by everyone, instead of each team member working in their own 3D model - Open BIM (BIM 3)		
Yes	41	74.5
No	14	25.5
Total	55	100.0
Application of BIM software for BIM 3		
Yes	10	18.2
No	45	81.8
Total	55	100.0

Source: Fieldwork, 2019

C. Factors affecting adoption of BIM

When asked if lack of knowledge was the greatest hindrance to adoption, 27.3% slightly agreed, while 38.2 totally agreed. Combined, this meant two thirds (65.5%) agreed in different measures Also 18.2% slightly disagreed and 16.4%total disagreed. This meant that one third (34.5%) disagreed (in different measures). This is illustrated in Figure 1.

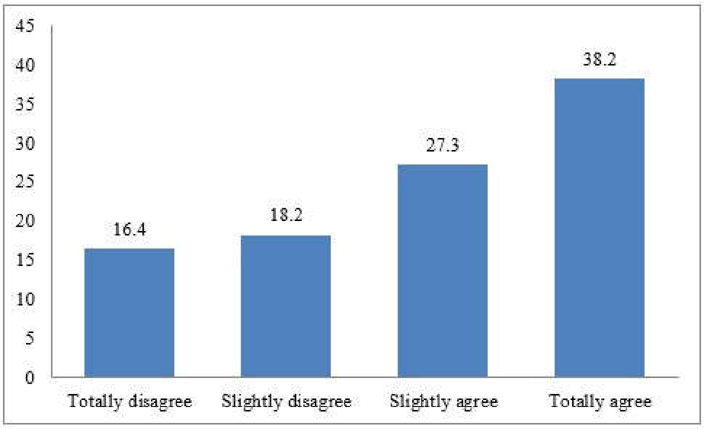

Figure 1: Lack of knowledge among architects as greatest hindrance
Source: Fieldwork, 2019

Respondents were asked if cost of equipment and infrastructure was the greatest hindrance to adoption. Those who slightly (29.6%) or totally (31.5%) disagreed that this was so, were the greater majority (61.1%). The minority (38.9%) of respondents, did not know (5.6%), slightly agreed (24.1%), or totally agreed (9.3%). This is illustrated in Figure 2.

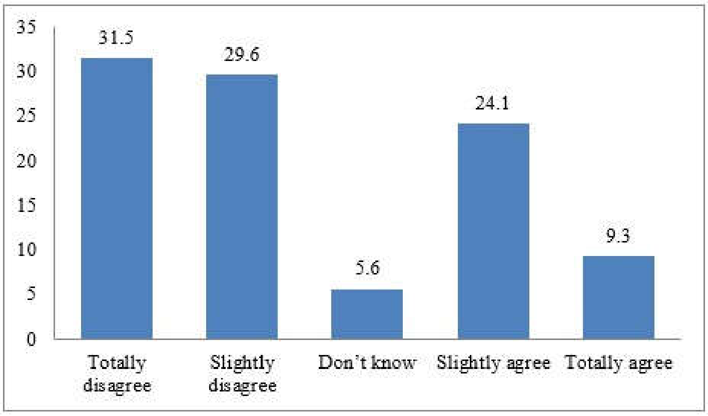

Figure 2: Cost of purchasing equipment and infrastructure as the greatest hindrance
Source: Fieldwork, 2019

Respondents were also asked if unavailability of equipment and infrastructure was the greatest hindrance to adoption. Again, the greater majority (63.6%) disagreed that this was so. Of this 29.1% slightly disagreed, while 34.5% totally disagreed. On the other hand, 3.6% did not know, 20% slightly agreed and 12.7% totally agreed. These were the minority (36.4%). This is illustrated in Figure 3.

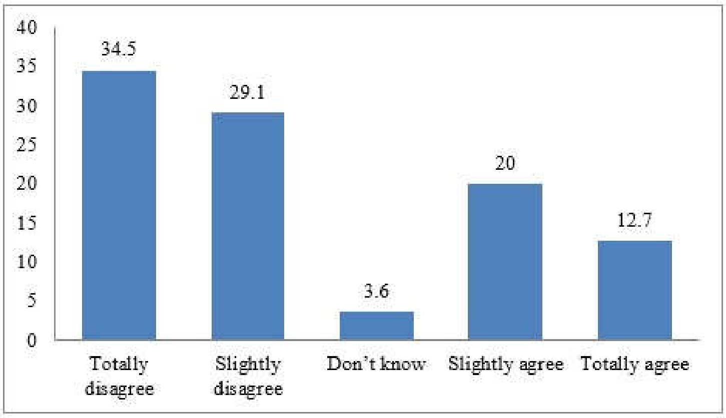

Figure 3: Unavailability of equipment and infrastructure as the greatest hindrance
Source: Fieldwork, 2019

When respondents were asked if lack of training opportunities was the greatest hindrance to adoption, 34.5% slightly agreed, while 32.7% totally agreed. This was the larger majority (67.3%). Also, one third (32.7%) disagreed. This comprised of 21.8% who slightly disagreed and 10.9% who totally disagreed. This is illustrated in Figure 4.

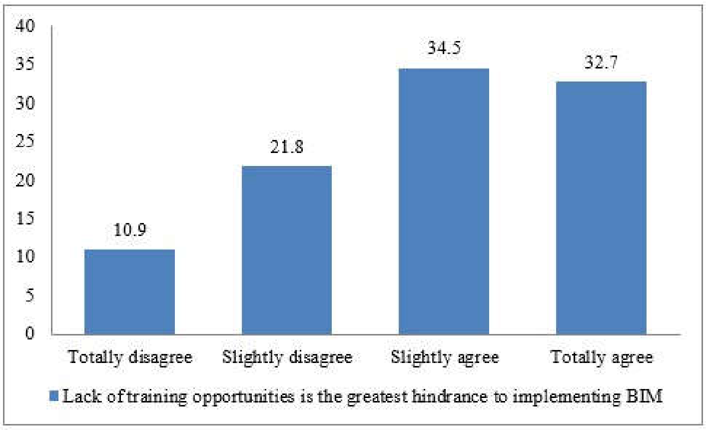

Figure 4: Lack of training opportunities as the greatest hindrance
Source: Fieldwork, 2019

DISCUSSION

It was found that there was a high level of awareness of BIM terminologies, software and uses, among respondents in the study area. Almost all respondents (95%) indicated knowledge of the term 'Building Information Modelling'. This proportion became reduced when awareness of the different levels of BIM was examined (BIM 1-89.1%, BIM 2- 72.7%, BIM 3- 74.5%). The incorporation (in the questionnaire) of the description of BIM levels was done to correctly operationalize the concept of BIM in the research. The results agreed with other findings which suggested high levels of awareness of the technology in Nigeria (Ibem, Uwakonye, Akpoiroro, Somtochukwu, & Oke, 2018; Hamma-adama, Kouider, & Salman, 2018; Dare-Abel, Igwe, & Ayo, 2014).

Aside from Level 0 BIM, which 89% of respondents indicated they practiced, the levels of adoption of the other levels investigated in the study were very low (BIM 1-29.1%, BIM 2-18.2%, BIM 3-18.2%). This indicated very low levels of adoption beyond Level 0 BIM. This agrees with evidence found in literature on BIM adoption in developing countries (Buiab, Merschbrockb, & Munkvold, 2016). However, with no case studies accompanying the results, even the adoption rates claimed for levels 1, 2 and 3 could not be verified. It is to be noted that in countries with high adoption rates, BIM-3 level of adoption is still rare. It is significant that though BIM implementation in the UK has reached high levels, the UK government's mandate for implementing BIM is still at level 2 with promise to attain level 3 in the future (Lorek, 2018). It may therefore be that some respondents didn't fully understand the question asked. Furthermore, this agreed with Jung and Lee, (2015) which stated that in the Middle East/Africa, respondents still considered their status of BIM adoption to be in the "beginner phase."

Analysis of respondents' opinions on factors which influenced adoption of BIM showed that the larger proportion agreed that lack of knowledge and lack of training opportunities were the topmost hindrances to adoption of BIM in the area. This agreed with related studies (Ogunmakinde & Umeh, 2018; Abubakar, Ibrahim, Kado, & Bala, 2014; Hamma-Adama & Kouider, 2018). Similarly, a larger proportion of respondents disagreed that cost and availability of equipment and infrastructure were the greatest barriers to adoption. This is at variance with some of the studies reviewed. It may be because the respondents were sufficiently able to purchase equipment, software and infrastructure. It could also be that costs of these items had come down to affordable levels when compared to the situations that existed at the time the reviewed studies were conducted. It is to be noted that the questions asked (in this study) were focused on the greatest barriers to adoption. The results indicated that there was the need to particularly focus on education and training as means for encouraging implementation and increasing adoption of BIM.

The implications of these findings were that for improved adoption of BIM in the study area to occur, it was imperative that the Imo State chapter of the Nigeria Institute of Architects organise BIM training workshops for her members. These will become the vehicles for driving update of architects' knowledge of the technology. Equally, there is the need for architectural educators in Institutions who train the architects to include BIM training in the tertiary education curricula. This is necessary if the products of these institutions would be suitably equipped for the work environment they will graduate into. Also, governments at Federal and State levels should partner with industry stakeholders to create enabling legislation on standards and use of BIM. This is because of the documented benefits BIM practices bring to procurement and construction. The involvement of government had been shown to be a critical success factor in advanced adopter countries. Buoyed by strategic interest and government support, architectural education regulators should reinforce inclusion of BIM training in architectural education curricula. This would help to stimulate an increase in the pace of adoption of BIM among architects.

Verified case studies of actual usage of BIM in the architectural design process were not available for use in the research. Without this, user opinions alone may not be sufficient for giving a complete description of the studied phenomenon. Also, a suggested area for further research would be the state of inclusion of BIM education into the curriculum for architectural education in Nigeria. This is important because literature has shown that in countries that have made great progress with BIM adoption, BIM education in higher institutions seemed to play an important role (Hamma-adama & Kouider, 2019; Edirisinghe & London, 2015). The results of such study, if applied, could also help encourage the process of adoption in the country.

CONCLUSION

Building Information Modelling is becoming the new CAD language and a required expertise in the building industry. As a result, the level of awareness and adoption of BIM in Imo State, Nigeria was studied. The impact of several factors on adoption of BIM amongst architects in the study area was also examined. From the results, it can be concluded that there was a high level of awareness of BIM terminologies, software and uses in the study area. Also, BIM was mostly practiced at Level 0 BIM, among the respondents. That implies that most did not really practice BIM, but rather, BIM software was used for design and production of drawings. On the other hand, there was very low adoption at levels 1, 2 and 3 of BIM. Lack of knowledge and lack of training opportunities were indicated to be the topmost hindrances to adoption of BIM in the area. Conversely, the Cost and availability of equipment and infrastructure required to implement BIM were not viewed as the greatest deterrents to adoption in the study area.

It is expected that the results of this study will lead to a more complete picture of the status of awareness and adoption of BIM in Nigeria. Having a more complete picture, it is expected, will aid better policy making by the relevant stakeholders in the industry. Also, the application of lessons drawn from the experiences of other countries will be helpful in achieving increased adoption of BIM, and thus experiencing the benefits of adoption seen in those climes. The recommended increased efforts towards education and legislation by relevant stakeholders is vital in this regard. When this happens, the industry will not only be kept abreast of vital skills that keep it competitive with the rest of the world, it will also achieve real tangible cost benefits for its clientele.

REFERENCES

Abubakar, M., Ibrahim, Y. M., Kado, D., & Bala, K. (2014). Contractors Perception of the Factors Affecting Building Information Modelling (BIM) Adoption in the Nigerian Construction Industry. *International Conference on Computing in CivilL And Building Engineering (23-25 June, 2014)* (pp. 167-178). Orlando, Florida, USA: American Society of Civil Engineers (ASCE). Retrieved from https://pdfs.semanticscholar.org/eddd/5e764a28e4620c6db6d088b75398d

Achimugu, P., Oluwagbemi, O., & Oluwaranti, A. (2010). An Evaluation of the Impact of ICT Diffusion in Nigeria's Higher Educational Institutions. *Journal of Information Technology Impact, 10*(1), 25-34. Retrieved June 1, 2015, from http://www.jiti.com/v10/jiti.v10n1.025-034.pdf

Amuda_Yusuf, G., Adebiyi, R. T., & Isa, B. M. (2018). BIM Awareness and Adoption by Construction Organizations in Nigeria. *ournal of Research Information in Civil Engineering, 15*(2), 2205-2224.

Autodesk Inc. (2019). *What are the benefits of BIM?* Retrieved from Autodesk: https://www.autodesk.com/solutions/bim/benefits-of-bim

Baker, J. (2012). The Technology–Organization–Environment Framework. In Y. Dwivedi, M. Wade, & S. Schneberger (Eds.), *Information Systems Theory: Explaining and Predicting Our Digital Society, Vol. 1.* New York, NY: Springer. doi:https://doi.org/10.1007/978-1-4419-6108-2_12

Begho, O. (2010). *i-Connect Project: Mobile solution to support ICT and Education in Nigeria*. Retrieved October 2013, from Futures-Ft: http://www.futuresoft-ng.com/IT-Talk/Articles/ict-education-africa/

BIM Africa. (2022). *The African BIM Report.* Research and Development Committee, BIM Africa. Retrieved from www.bimafrica.org/reports/

Buiab, N., Merschbrockb, C., & Munkvold, B. E. (2016). A review of Building Information Modelling for construction in developing countries. *Procedia Engineering, 164*, 487 – 494. Retrieved November 16, 2019, from https://cyberleninka.org/article/n/1468225.pdf

Cambridge University Press. (2022). *Awareness*. Retrieved from Cambridge Dictionary: https://dictionary.cambridge.org/dictionary/english/awareness

constructionplacements.com. (2022, December). *15 Best BIM Software* . Retrieved from Construction Placements: https://www.constructionplacements.com/bim-software/#gsc.tab=0

Dare-Abel, O. A., Igwe, J. M., & Ayo, C. K. (2014). Proficiency and Capacity Building of Human Capital in Architectural Firms in Nigeria. *International Journal of Architecture and Design, 25*(2), 1133-1139.

Department of Innovation, Industry, Science and Research. (2010). *Issues paper: Digital modelling and the built Environment.* Canberra: Dept. of Innovation, Industry, Science and Research.

Dictionary.com. (2022, December). *Adoption*. Retrieved from Dictionary.com: https://www.dictionary.com/browse/adoption#:~:text=Most%20generally%2C%20adopt%20 means%20to%20choose%20or%20take,of%20adopting%2C%20or%20the%20state%20of%20having%20adopted.

DPR Construction. (2010). *The Four Levels of BIM*. Retrieved April 5, 2019, from DPR Review Fall/Winter 2010: https://www.dpr.com/media/review/fall-winter-2010/the-four-levels-of-bim

Edirisinghe, R., & London, K. (2015). Comparative Analysis of International and National Level BIM Standardization Efforts and BIM adoption. *Proceedings of the 32nd CIB W78 Conference 2015, 27th-29th 2015,* (pp. 149-158). Eindhoven, The Netherlands: CIB.

Froise, T., & Shakantu, W. (2014). Diffusion of Innovations: An Assessment of Building nformation Modelling Uptake Trends in South Africa. *Journal of Construction Project Management and Innovation, 4*(2), 895-911. Retrieved from https://journals.co.za/deliver/fulltext/jcpmi/4/2/jcpmi_v4_n2_a2.pdf

Gambatese, J. A., & Hallowell, M. (2011). Enabling and measuring innovation in the construction industry. *Construction Management and Economics, 29*(6), 553-567.

Hamma-Adama, M., & Kouider, T. (2018). A Review on Building Information Modelling in Nigeria and Its Potentials. *International Journal of Civil and Environmental Engineering, 12*(11), 1113-1119.

Hamma-adama, M., & Kouider, T. (2019). Comparative Analysis of BIM Adoption Efforts by Developed Countries as Precedent for New Adopter Countries. *Current Journal of Applied Science and Technology, 36*(2), 1-15. doi: https://doi.org/10.9734/cjast/2019/v36i230224

Hamma-adama, M., Kouider, T., & Salman, H. (2018). State Of Building Information Modelling (BIM) Adoption In Nigeria. *A working paper at the ARCOM 2018 Conference, UK, 3-5 September* (pp. 334-343). Belfast, UK: ARCOM. Retrieved from http://www.arcom.ac.uk/-docs/archive/2018-working-papers.pdf

Hamma-adama, M., Salman, H., & Kouider, T. (2017). Diffusion of Innovations: The Status of Building Information Modelling Uptake in Nigeria. *Journal of Scientific Research & Reports, 17*(4), 1-12.

Hardie, M., & Newell, G. (2011). Factors influencing technical innovation in construction SMEs: an Australian perspective. *Engineering, Construction and Architectural Management*, 618-636.

Hobbs, J. (2018, October 10). *The Advantages of CAD (Computer-Aided Design)*. Retrieved from cad crowd: https://www.cadcrowd.com/blog/the-advantages-of-cad/

Hobbs, J. (2019, May 3). *2D vs 3D: What You Need to Know*. Retrieved from cad crowd: https://www.cadcrowd.com/blog/2d-vs-3d-cad/

Ibem, E. O., Uwakonye, U. O., Akpoiroro, G. O., Somtochukwu, M., & Oke, C. A. (2018, September). Building information modeling (BIM) adoption in architectural firms in Lagos,. *International Journal of Civil Engineering and Technology, 9*(9), 902–915.

Jung, W., & Lee, G. (2015). The Status of BIM Adoption on Six Continents. *International Journal of Civil, Structural, Construction and Architectural Engineering, 9*(5), 406-410.

Kori, S. A., & Kiviniemi, A. (2015). Toward Adoption Of BIM In The Nigerian AEC Industry; Context Framing, Data Collecting And Paradigm For Interpretation. *9th BIM Academic Symposium & Job Task Analysis Review, 7-8 April 2015* (pp. 34-41). Washington DC, USA: Academic Interoperability Committee. Retrieved from http://coremng.dcp.ufl.edu/website/cacim/2015bimeducation/2015AiCProceedings.pdf

Lawrence , P., & Scanlan, J. (2007). Planning in the dark: why major engineering projects fail to achieve key goals. *Technology Analysis & Strategic Management, Management , 19*(4), 509-525.

lectera.com. (2022, December). *Diffusion of innovation*. Retrieved from Lectera: https://lectera.com/info/articles/diffusion-of-innovation

Lorek, S. (2018, July 7). *What is BIM (Building Information Modeling)*. Retrieved from Constructible: https://constructible.trimble.com/construction-industry/what-is-bim-building-information-modeling

Mandhar, M., & Mandhar, M. (2013, December). BIMing The Achitectural Curricula – Integrating Building Iinformation Modelling (BIM) in Architectural Education. *International Journal of Architecture, 1*(1), 1-20.

McGraw Hill Construction. (2014). *Smart Market Report - The business value of BIM for construction in major global markets: How contractors around the world are driving innovation with building information modeling.* Bedford, MA: McGraw Hill Construction.

McPartland, R. (2014, November 1). *BIM Levels explained*. Retrieved from NBS: https://www.thenbs.com/knowledge/bim-levels-explained

merriam-webster.com. (2022). *Awareness*. Retrieved from Merriam-Webster: https://www.merriam-webster.com/dictionary/awareness

Mordue, S. (2019, April 23). *Explaining the levels of BIM*. Retrieved from CIOB: https://www.bimplus.co.uk/analysis/explaining-levels-bim

neostrom.in. (2022, December). *Diffusion of Innovation Theory – 5 Groups, 4 Elements & Examples*. Retrieved from Neostrom: https://neostrom.in/diffusion-of-innovation-theory/#:~:text=The%20diffusion%20of%20innovation%20theory%20was%20first%20introduced,product%2C%20following%20a%20series%20of%20%E2%80%9Cwaves%E2%80%9D%20or%20phases.

Newton, K., & Chileshe, N. (2012). Awareness, usage and benefits of Building Information Modelling (BIM) adoption – the case of the South Australian construction organisations. In S. D. Smith (Ed.), *Procs 28th Annual ARCOM Conference* (pp. 3-12). Edinburgh, UK: Association of Researchers in Construction Management. Retrieved November 16, 2019, from https://www.academia.edu/27588671/Awareness_usage_and_benefits_of_building_information_modelling_BIM_adoption-the_case_of_South_Australian_construction_organizations

Ogunmakinde, O. E., & Umeh, S. (2018, September). Adoption of BIM in the Nigerian Architecture Engineering and Construction (AEC) Industry. *Paper presented at the 42nd Australasian Universzities Building Education Association (AUBEA) Conference.* Singapore: AUBEA. Retrieved June 15, 2020, from ResearchGate:

https://www.researchgate.net/publication/328031625_Adoption_of_BIM_in_the_Nigerian_Architecture_Engineering_and_Construction_AEC_Industry/link/5bb3de91a6fdccd3cb82773a/download

Onungwa, I. O., & Uduma-Olugu, N. (2017). Building Information Modelling and Collaboration in the Nigerian Construction Industry. *Journal of Construction Business and Management*, 1-10. Retrieved from http://journals.uct.ac.za/index.php/jcbm/article/view/53

Osakwe, R. (2012, December). Challenges of information and communication technology (ICT) education in Nigerian public secondary schools. *Education Research Journal*, 388-391. Retrieved June 3, 2015, from http://resjournals.com/ERJ/Pdf/2012/Dec/OSAKWE.pdf

Victor, L. (2019, July 10). *BIM Mturity Levels Explained- Level 0, Level 1, Level 2, Level 3*. Retrieved from united-bim.com: https://www.united-bim.com/bim-maturity-levels-explained-level-0-1-2-3/

Wan Mohammad, W. N., Abdullah, M. R., Ismail, S., & Takim, R. (2018). Overview of Building Information Modelling (BIM) adoption factors for construction organisations. *IOP Conf. Series: Earth and Environmental Science* (pp. 1-8). IOP Publishing. Retrieved November 16, 2019, from https://www.researchgate.net/publication/324444966_Overview_of_Building_Information_Modelling_BIM_adoption_factors_for_construction_organisations/fulltext/5ace11d84585154f3f42c537/324444966_Overview_of_Building_Information_Modelling_BIM_adoption_factors_f

Wong, K.-d., & Fan, Q. (2013). Building information modelling (BIM) for sustainable building design. *Facilities, 31*(3/4), 138-157. doi:10.1108/02632771311299412

Yang, L. R. (2007). Exploring the links between technology usage and project outcomes. *Construction Management and Economics, 25*(10), 713-725.

Zhang, L., Chu, Z., He, Q., & Zhai, P. (2019). Investigating the Constraints to Buidling Information Modeling (BIM) Applications for Sustainable Building Projects: A Case of China. *Sustainability , 11, 1896, 11*(1896), 1-17. doi:doi:10.3390/su11071896